LUNAR PHYSICAL PARAMETERS STUDY

ORDER No. 61-421

PARTIAL REPORT NO. 10

ACOUSTIC VELOCITY

BREADBOARD TESTS

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Contract NASW-6

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ACOUSTIC VELOCITY - BREADBOARD TESTS

Summary

Surface velocity measurements with breadboard apparatus have been made (in air) on dry sandy soil, moist clay, loose dry sand, and concrete slab. Subsurface measurements were made in moist clay, and in stacked cubes of hard rock. Also, a subsurface test was made with the sonde buried in loose sand. These tests included use of both geophones and accelerometers as detectors, and both explosive and dropped weight as acoustic source. The explosive source was tested wherein the gases were directly exposed to the material under test, and wherein the gases were confined within a rubber diaphram and exhausted away from the material.

The results of these tests, with additional consideration for weight and size limitations, and environmental conditions, indicate that geophones on the surface and an accelerometer in the downhole sonde are preferable as detectors. The source should preferably be of the explosive type. However, vacuum tests with the breadboard equipment, presently being made by Jet Propulsion Laboratory, will have to dictate the final choice as to whether or not the explosive can be used, and if so, whether or not it be of the enclosed type.

Preliminary reports from the vacuum tests indicate that the gas wave given off from the open type explosive source does not produce objectionable signals at the geophone detectors.

1:794.36-1

However, this source holder, when used in vacuum, recoils violently from the surface and is therefore objectionable. The enclosed type source holder (having hemispherical rubber diaphram between source and surface, and having gases vented away from the surface) was found to be reasonably stable. These vacuum tests were made on unconsolidated, fine-grain sand.

The framework of the open type explosive source holder used in these tests is shown in Fig. 19. Six (6) sources (DuPont X-311B Mild Electric Initiators) were mounted in the clips provided, and the "wire-breaks" for sync. (#34 wire) were mounted on terminals near the source. Each of the six "compartments" were then packed with glass wool. The compartmenting and the glass wool were used to prevent detonation of one explosive by another. These provisions were found to be more than adequate for the purpose.

For the enclosed explosive source tests, the aluminum "shell" shown in Fig. 20 was used. The aforementioned source holder was mounted inside the shell, and leads brought out on teflon feed-thru terminals. A hemisphere of rubber, 5 in. dia. by 1/8 in. thick, was clamped over the opening of the aluminum "shell". The unit was then placed on the surface with the rubber hemisphere making contact with the surface. The gases from the explosion were vented out the top through a tube. Use of an enclosed type source of this type will probably require that it be mechanically attached to the spacecraft. This is undesirable since the attachment offers an acoustic path through the spacecraft to the detectors. However, there appears to be no alternative. Such attachment needs to assure that the source be placed in its correct position on the surface with a selected side down and to offer shock mounting, especially for vertical movement.

The acoustic energy from an impact hammer has been found to be reasonably satisfactory for this measurement if the hammer is made to impact against a solid object which has been placed on the surface. An impact directly against the surface is not satisfactory. The major problem with this type source is the extreme weight limitation and/or mechanical manipulation requirements. Also, the source needs to be acoustically "quiet" immediately before impact. It was found that a 2 lb. weight dropped from a height of 1 ft. could approximately simulate the explosive source. Time-of-impact on such a source can be detected by use of an accelerometer mounted on the "hammer" (or on the impact block).

Test Results, General

Results of tests performed under various conditions with various materials, sources, and detectors are indicated in Figs. 2 thru 18. The receiver amplifier system used, whether it be for geophone or accelerometer, is shown in Fig. 1. Recordings of received signal were made using a Tektronix 535 oscilloscope and a Polaroid camera. In most cases, the oscilloscope vertical gain was adjusted as high as practical, depending on background acoustic noise. When using the explosive source, the oscilloscope was synchronized by use of a "wire-break" method, the wire being located very near the explosive. When using a dropped weight as source, the synchronizing signal came from an accelerometer mounted on the weight. Synchronization from the "wire-break" was found to be considerably more accurate and repeatable than that from the mounted accelerometer.

The results shown in the aforementioned figures were selected as being the most representative and informative of a much larger number of tests. Results of the other tests are available in the "raw" data form; many of these were made for interpretation studies.

Most of the conditions under which the data on Figs. 2 thru 18 were taken are indicated on the figures. However, further discussion as to the purpose, significance, and interpretation of these tests is given in following paragraphs.

Surface Tests

The tests shown in Figs. 2, 3, and 4 were performed on a dry, sandy, roadbed. The test in Fig. 2 was made to determine the actual velocity of the material and from this test the compressional wave (P-wave) velocity was estimated at 950 ft/sec. In this case one (1) X-311B explosive source was buried 6 in. deep. Data in Fig. 3 was made under the same conditions, except that the explosive source and holder were located on the surface.

In this case, it may be noted that rather high amplitude and high frequency energy was detected at times corresponding to the air wave velocity, making it difficult to detect the time-of-arrival of ground wave energy.

The test indicated in Fig. 4 was made to determine whether or not location of the spacecraft legs in the proximity of the source and one detector could be tolerated. The acoustic path through the spacecraft was simulated by use of a tripod made of 3/4 in. steel pipe. The signal from Detector No. 2 (upper trace) shows considerable energy arriving at the second detector which had to have traveled the metal path due to its early arrival. Fig. 4 and Fig. 3 offer a direct comparison of signals with and without the "spacecraft" legs. It is felt that to eliminate this problem by acoustic decoupling methods within the spacecraft legs would be impractical. Thus, it has been recommended that the source be located under the spacecraft and approximately equi-distant from the three legs. In this arrangement, the first detector would be mounted near one leg and the other mounted in the surface density device and located several feet beyond the first detector.

Figs. 5 thru 8 indicate conditions and results of tests on a concrete slab. Figs. 5 and 6 offer a comparison of the signals recorded when "hammer" source is directed against the surface and against the edge of the slab. The "hammer" was a 2 lb. weight with impact velocity roughly equivalent to 1 ft.

free-fall. Three repeat photos are indicated for each hammer test since some variations will be found due to changes in scope synchronization and signal generated with different hammer blows. The first detectable energy in Fig. 5 would indicate approximate velocity of 8300 ft/sec. However, it may be noted that Fig. 6 offers velocity measurement of approximately 16,600 ft/sec. This would indicate that compressional wave energy is not detected in the first case, but is readily detected with the hammer blow against the edge. The relative amplitudes of the first half cycles of signals in Fig. 6 indicate an apparent increase in signal with distance. This is probably due to the difference in sensitivity of the geophones to the indicated frequencies, and to the separation (in time) of the P-wave and Rayleigh wave energy with distance traveled.

Fig. 7 offers results of the same set-up as Fig. 5 except that the open-type explosive source is substituted for the weight drop. Here again, first-detected energy indicates approximately 8300 ft/sec. velocity.

Verification of both the Rayleigh wave and P-wave velocities can be seen in Fig. 8 where accelerometers are used with the explosive source. Here, the very-high-frequency, low-amplitude P-wave is indicated on both accelerometers as well as the high-amplitude, lower-frequency Rayleigh wave, having velocities of approximately 16,600 and 8300 ft/sec., respectively.

It is felt that the concrete slab represents about the poorest condition one might encounter for generating P-wave energy in a frequency range suitable for a geophone. Obviously, the P-wave energy here is too high in frequency for the geophone. In such materials as concrete, the accelerometer has the advantage. However, the advantage is not considered strong enough to offset the problems with the accelerometer in low velocity materials. With the geophone in the concrete, one can at least be assured of detecting Rayleigh wave energy which, with experience and possibly other information, may be recognized as Rayleigh wave, allowing a valid velocity determination. With a misinterpretation of the type of wave, one has an error of approximately +90% (or -47%, as the case may be), assuming P-wave to Rayleigh wave velocity ratio to be 1.9.

Figs. 9 thru 12 are results of tests made on a clay type soil where considerable moisture was present except in the top two or so inches, the surface being quite dry and cracked. Surface measurements indicate approximately 1250 ft/sec. velocity. (Downhole measurement, Fig. 18, indicates velocity of 1550 ft/sec.)

Fig. 9 and 10 offer a comparison of signals from vertical impact as against horizontal impact. Since no essential change is indicated (other than amplitude), one would assume the detected energy to be P-wave.

Substitution of the open-type explosive source for the hammer offers the signals recorded in Fig. 11. It may be noted here that the apparent signal frequency is higher than with the hammer source and that the first half cycle (positive) on the second detector is hardly detectable. Comparison of the two detector signals is helpful in making the interpretation. This record offers an explanation as to why it is desirable to utilize the highest detector amplifier gain practical, limited only by background acoustic or electrical noise.

Fig. 12 is the recorded signal for the same conditions as Fig. 11, except that accelerometers are used instead of geophones. Here the first half cycle on the second detector is lost. The most accurate and valid measurement here would utilize the distance to the first detector and the time of the first recorded signal on that detector.

Fig. 13 and 14 indicate results from tests in loose, dry sand. This material, having velocity lower than air, required insertion of a steel plate as shown in Fig. 13 to prevent reception of the first arrival air wave, both with explosive source and hammer type source. In the case of the hammer type source, the impact against the sand generated signals too low in frequency to be utilized for velocity measurements with the practical limitations in spacings in the lunar application. However, it was found that an impact against a small metalic plate resting on the surface generates usable signals. The impact against a plate also generates a rather strong air wave, similar to that generated by the explosive source. Insertion of the high density steel plate near the source, and between the source and detectors, allows measurements of sand velocities, even in air. The velocity of the sand was determined to be approximately 550 ft/sec. This is indicated in Figs. 13 and 14 and was also verified by vertical and lateral hammer impacts.

In Fig. 13, the strong negative going "breaks" are the responses from signals traveling in the sand. (It should be noted here that the geophone connections for tests of Figs. 13, 14, and 15 were in reverse polarity from those used in all other geophone tests herein shown.) The relatively low amplitude positive-going first "break" in Fig. 13 is due to arrival of a weak airwave, the path of which was around the edges of the steel plate, possibly reflected by the walls of the container.

The amplifier gains used in Fig. 13 and several other tests indicated in this report are obviously much higher than was necessary, or even desirable, for the conditions of the particular test. However, since the conditions of the material to be tested on the lunar application will not be known and amplifier gain adjustments will not be available, it is considered necessary that these tests be run with the highest possible gains, limited only by acoustic background noises.

In anticipation of problems with the open-type explosive source holder when tested in vacuum, an enclosure consisting of an aluminum housing, but with a rubber hemisphere for contact to the surface, was tested in the sand and on the concrete slab. Results of these tests are indicated in Figs. 14 and 15. Fig. 14 and 13 were under similar conditions except for the enclosure of the source. (The time-scale on the records were different by a factor of 2.) Fig. 15 and 7 were also under similar conditions except for the enclosure. These two comparisons indicate that no major loss of data is incurred by the insertion of the rubber between the source and the surface, at least not in loose sand nor in the concrete slab.

The breadboard design incorporated a geophone with the surface density unit as second detector. The geophone in this assembly was compared with a separate geophone by placing them side by side on the ground and looking for wave shape difference in the first cycle of a signal from a hammer impact. An insignificant difference was indicated. This test included placement of the density-geophone combination such that the geophone was positioned off vertical as much as 45°. The effects noted were considered minor.

Subsurface Tests

The source holder used in the downhole acoustic tests was the open type. The materials tested included the moist clay used in surface measurements, but containing a 1-1/2 in. hole, and a stack of Austin chalk and Carthage marble rocks, as shown in Fig. 16. The detector used was an Endevco Model 2213 accelerometer. The final breadboard sonde contained a Model 2221C accelerometer, the exchange made because of physical dimension and environmental problems with the Model 2213.

Fig. 17 shows results of tests under conditions similar to those in Fig. 16, except that a layer of sand, 1-1/2 in. thick, was placed on the "surface". The difference in travel time to the 3-1/2 ft. depth (0.6 - 0.33 = 0.27 ms for 1-1/2 in. of sand) corresponds to approximately 460 ft/sec. velocity for the sand. The layer of sand above a high velocity, high density material, plus the discontinuities at 1 ft. intervals due to the stacked blocks, are considered to be as detrimental for this measurement as one can anticipate as far as energy level is considered.

Signals in Fig. 18 indicate the results of subsurface tests in moist clay. These are considered idealized signals and indicate the advantage gained when the source can be directed toward the detector (as compared to the surface measurement).

Several other tests were performed with the sonde, the results of which are not attached (but are available in slide photographs). In one case the acoustic section of the sonde was buried in loose sand approximately 1 ft. deep. The unit was found to be very sensitive to first arrival energy from hammer impacts on the surface for lateral distance of at least 2 ft. Larger dimensions were not tested due to limited sample size; however, no problem is anticipated here.

Tests were made to determine if a problem would be encountered due to azimuthal directivity of the sonde detector relative to the direction to the source. Tests in the 1 ft. cubes of rocks could not be conclusive due to the close boundaries.

However, tests in the moist clay indicated some direction sensitivity at depths near 1 ft. or less. When the detector is located on the borehole wall opposite the source, there is a slight delay in first-arrival time and some loss in amplitude. Below the depth of 1 ft., there was little or no effect due to rotation of the sonde.

The original plans to use a miniature geophone in the downhole sonde have been canceled. Manufacturing problems plus operational failures made it undesirable to pursue this further. Also, the fact that the source is directed more or less toward the detector in the subsurface application, offering relatively high amplitude and high frequency signals at the sonde, allows satisfactory detection with an accelerometer.

Investigation of the signal received when the acoustic detector fails to make direct contact with the wall indicated that the received signal under this condition is considerably reduced in amplitude and frequency from that received when the detector is in good contact. It is assumed that comparison of signals for various depths will allow elimination of those taken under the "no-contact" condition.

Additional Tests and Comments

Several other tests were made, the results of which are not attached in this report. (However, original data sheets and films on these are available.) Attempts were made to eliminate air wave by placement of large amounts of glass wool on the surface over the area of test. The air wave was only partially reduced by this method. The use of a high density plate was found to be much more practical.

Several designs of enclosed source holder were tested. One factor learned from these was that the explosive gases should not be highly confined. Provision for reasonable venting is needed to assure against physical destruction of the holder.

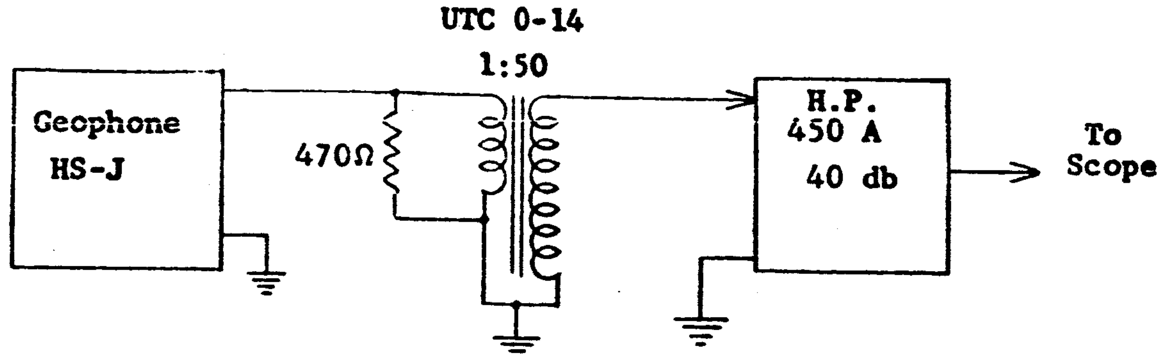
Some testing with the downhole sonde was done to determine if the "short circuiting" of acoustic energy through the mechanical attachment to the sonde would be a problem The 1/4 in. rod, used to manipulate the sonde, was held against the side of the borehole at the top of the hole while hammer impact signals were induced at the surface near the hole, and detected at the sonde. This was done both in hard rocks and in the moist clay hole. There was no apparent effect. However, it may be noted in Fig. 18 for the signal at 3-1/2 ft. depth (with the explosive source) that a low-amplitude, high-frequency signal is indicated very shortly before the main first break. This is possibly due to acoustic energy traveling the sonde and rod path. In this case, no problem exists in interpretation however, and it is believed that the decoupling and filtering which exists along the sonde path and in the accelerometer mount will normally allow differentiation between a sonde path signal and the correct signal.

The problem of recognizing whether or not P-wave (compressional wave) energy is being detected in the surface measurement has not been completely and satisfactorily resolved. Apparently, in low velocity materials (and thus low frequency signals) the P-wave energy is readily detectable and interpretation in this range would normally assume P-wave. However, in high velocity materials, the P-wave energy traveling laterally across the surface is of such high frequency and low amplitude, and attenuates so rapidly, that its detection is not assured. (The Rayleigh wave in such case should be detectable.) Thus, determination of the velocity and the type wave should be done by an experienced interpreter. A successful subsurface acoustic test would offer confirmation of interpretation of surface data.

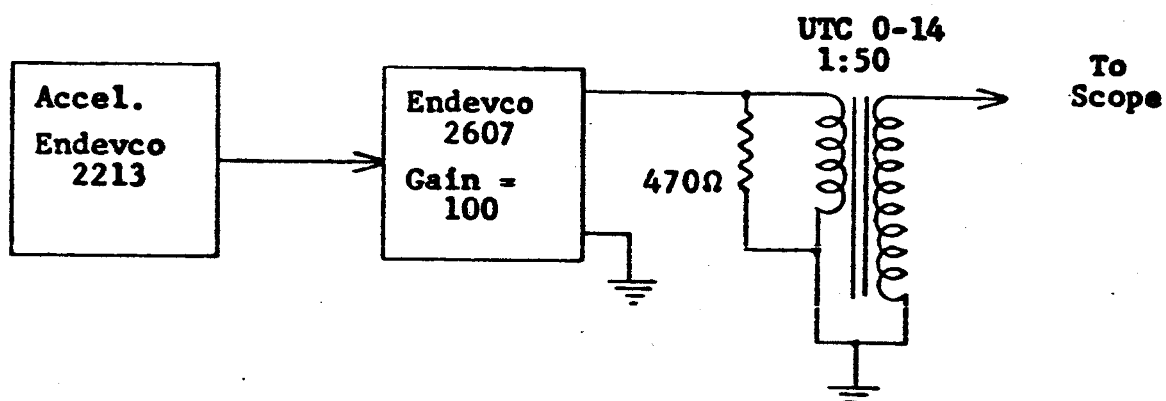
The list of equipment used in testing and test procedures was outlined in a previous report, "Outlines of Breadboard Test Experiments", and will not be repeated here. Also, interface data were given in a previous report, "Physical Parameters Instrumentation for Surveyor, Interface and Descriptive Information", dated April 21, 1961. One major change since this report was the replacement of the downhole miniature geophone with an accelerometer.

Also, it has been found desirable to use spacings for surface measurements that are in the minimum range of those outlined in aforementioned reports. In fact, if it becomes desirable, for other reasons, to use spacings as short as 3 ft. (3 ft. between source and Detector No. 1 and 6 ft. between source and Detector No. 2), this would be considered permissible. A slight loss in timing accuracy would be encountered in the high velocity range, but confidence in validity would be improved.

Design drawings for the Surface Density - Acoustic Detector combination, and for the subsurface sonde (including downhole acoustic detector) will be supplied to Jet Propulsion Laboratory under separate cover.



Geophone Amplifier System

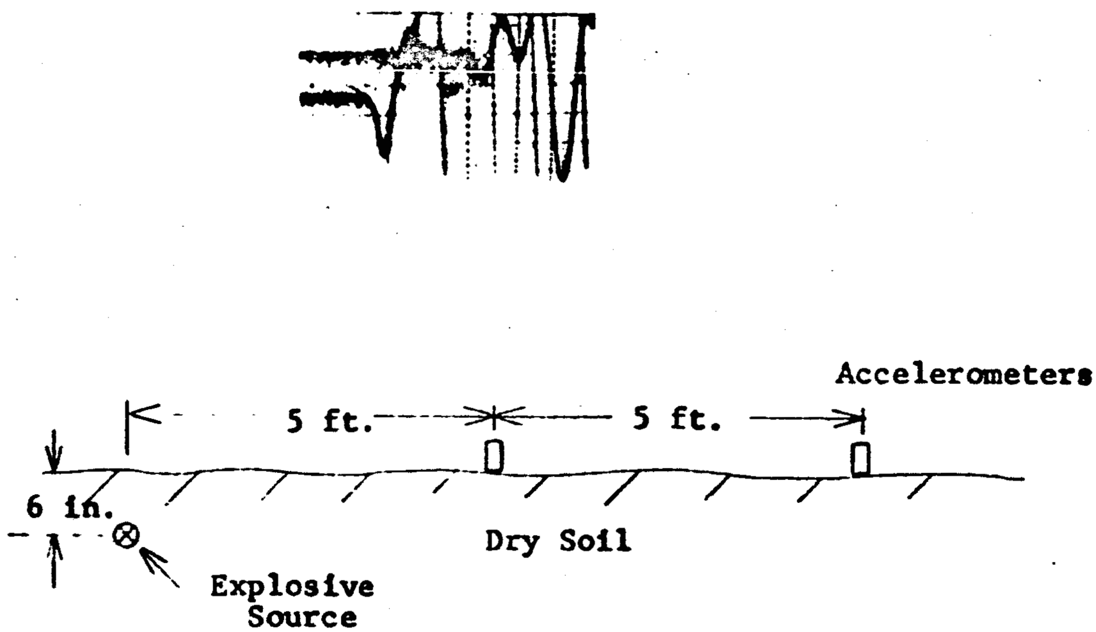


Accelerometer Amplifier System

FIGURE 1

DETECTOR AMPLIFIER SYSTEMS

1:794-53
1:794.36-16

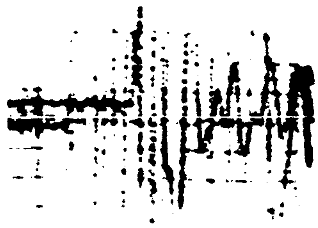


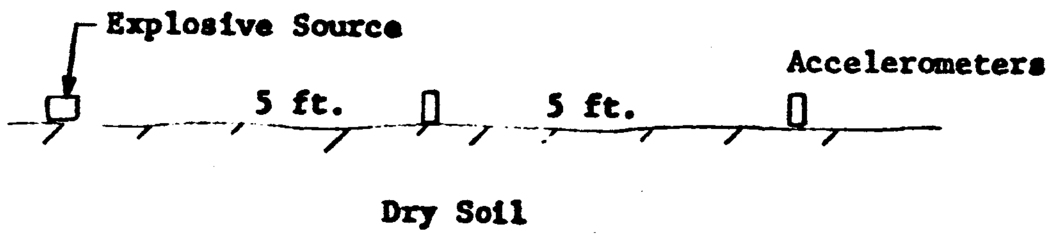
Sweep:	2 ms/div.
Scope Sensi.:	0.5 v/div.
Material Velocity:	950 ft/sec. (P wave)
Measured Velocity:	950 ft/sec. (P wave)

FIGURE 2

BURIED SOURCE - ACCELEROMETERS - DRY SOIL

1:794-54
1:794.36-17





Sweep: 2 ms/div.
Scope Sensi: 0.5 v/div.
Material Velocity: 950 ft/sec. (P-wave)
Measured Velocity: 1100 ft/sec. (Air wave)

FIGURE 3

AIR WAVE MEASUREMENT

1:794-55
1:794.36-18

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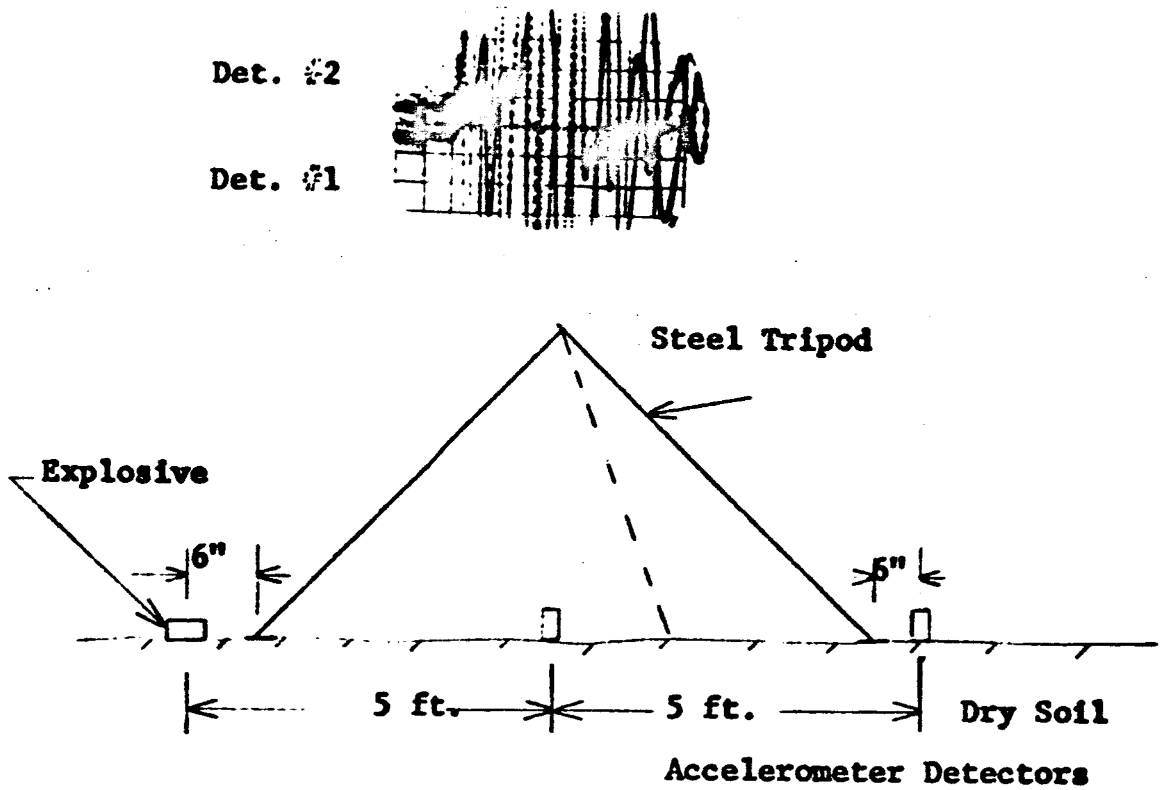
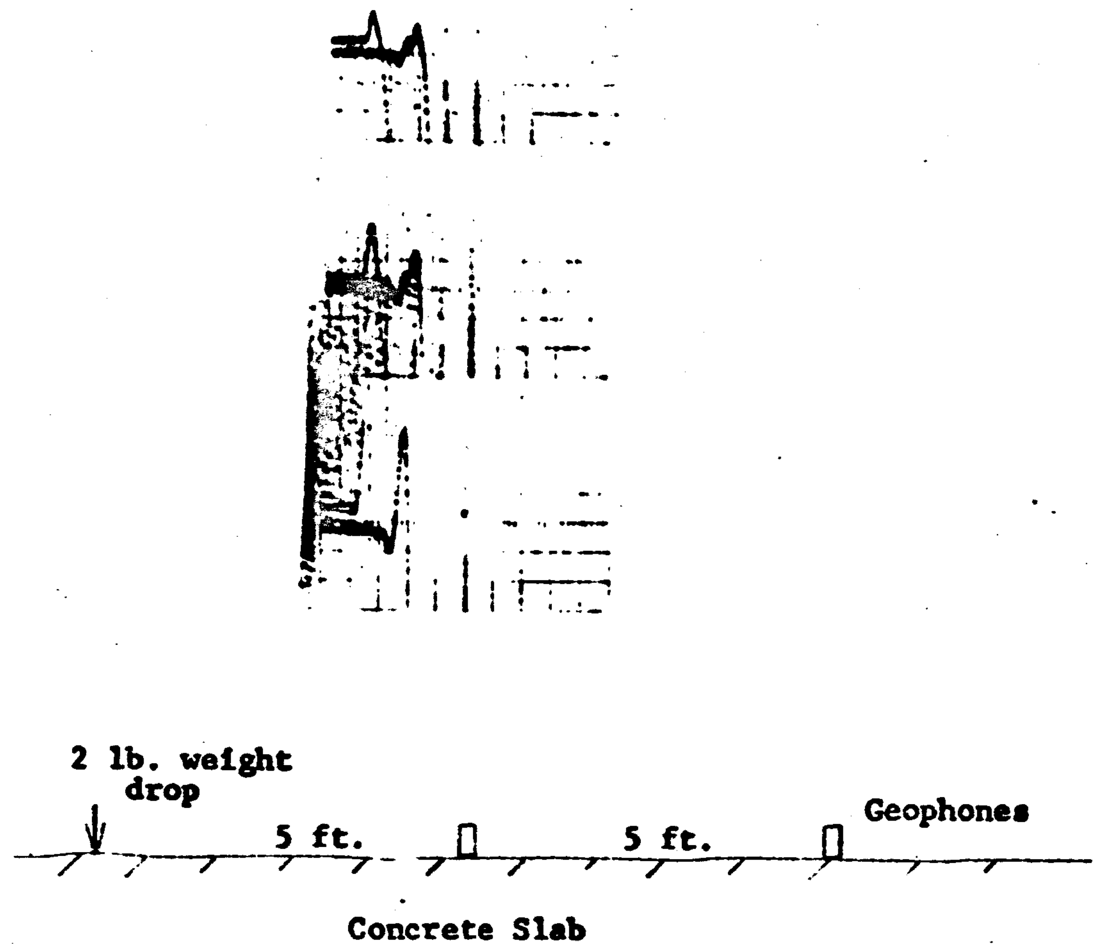


Sweep:	2 ms/div.
Scope Sensi.:	0.5 v/div.
Material Velocity:	950 ft/sec.
Measured Velocity:	?

FIGURE 4

SIMULATED SPACECRAFT TEST

1:794-56
1:794.36-19



Sweep:	0.5 ms/div.
Scope Sensi:	0.1 v/div.
Material Velocity:	16,500 ft/sec. (P-wave)
	8,500 ft/sec. (Rayleigh)
Measured Velocity:	8,300 ft/sec. (Rayleigh Wave)

FIGURE 5

WEIGHT DROP - SURFACE - CONCRETE

1:794-57
1:794.36-20

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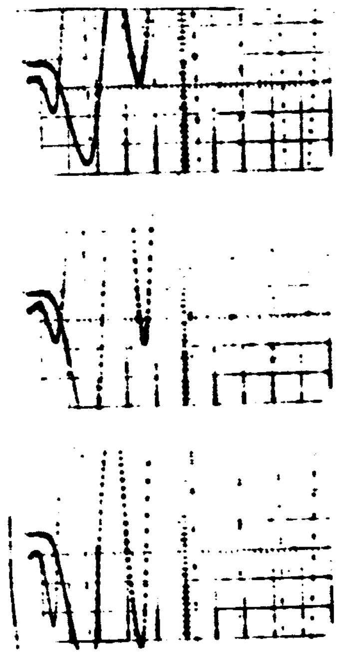
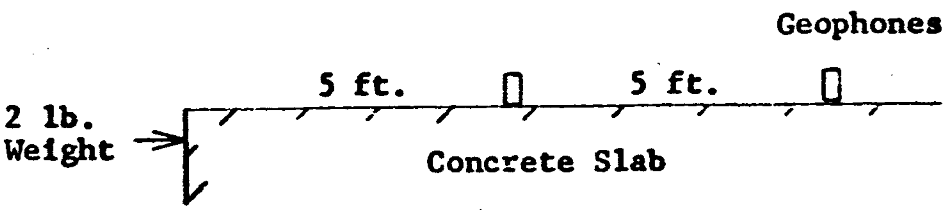


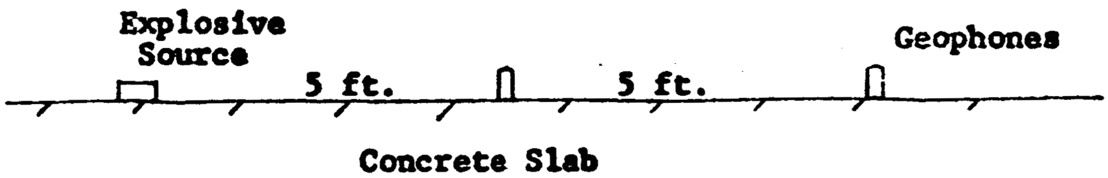


Sweep: 0.5 ms/div.
Scope Sensi.: 0.1 v/div.
Material Velocity: 16,600 ft/sec. (P wave)
Measured Velocity: 16,600 ft/sec.

FIGURE 6

LATERAL WEIGHT - CONCRETE

1:794-58
1:794.36-21



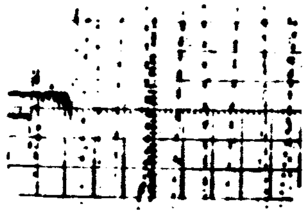
Sweep:	0.5 ms/div.
Scope Sensi:	0.2 v/div.
Material Velocity :	16,600 ft/sec. (P-wave)
Measured Velocity:	8,300 ft/sec. (Rayleigh)

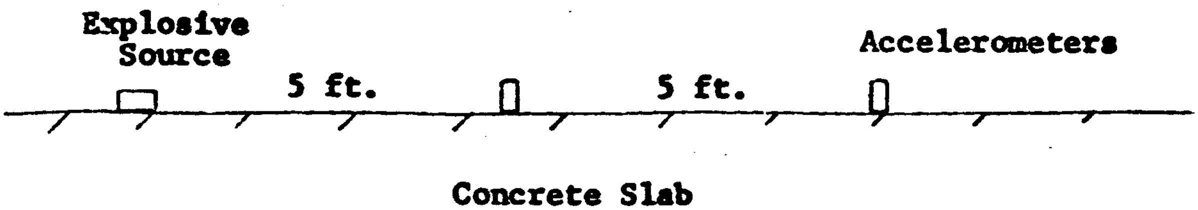
FIGURE 7

EXPLOSIVE SOURCE - CONCRETE - GEOPHONES

1:794-59
1:794.36-22

RE-ORDER No. 61-421





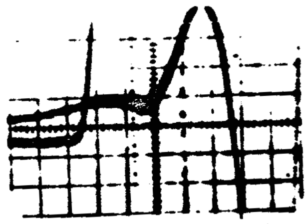
Sweep:	**0.5 ms/div.**
Scope Sensi:	**0.5 v/div.**
Material Velocity:	**16,600 ft/sec. (P-wave)**
Measured Velocity:	**16,600 ft/sec. (P-wave)**
	8,300 ft/sec. (Rayleigh)

FIGURE 8

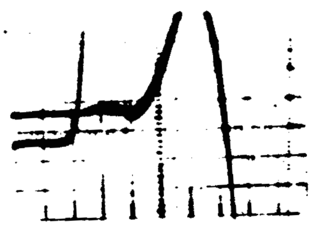
EXPLOSIVE SOURCE - CONCRETE - ACCELEROMETERS

1:794-60
1:794.36-23

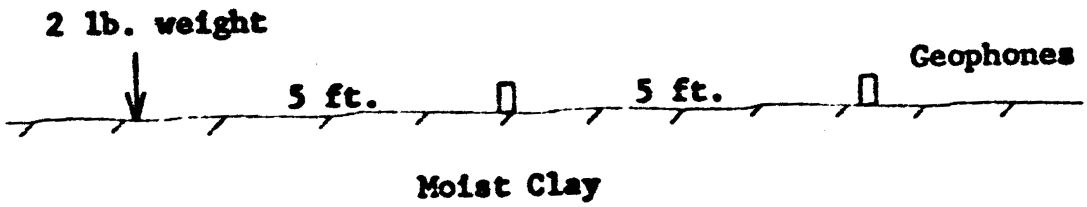
Sweep: 5 ms/div.
Sensi: 0.5 v/div.



Sweep: 2 ms/div.
Sensi: 0.2 v/div.



Sweep: 2 ms/div.
Sensi: 0.2 v/div.

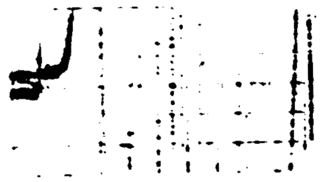


Sweep: (Given above)
Sensi: (Given above)
Material Velocity: 1250 ft/sec. (P-wave)
Measured Velocity: 1250 ft/sec. (P-wave)

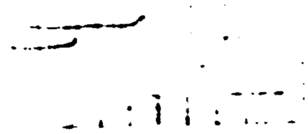
FIGURE 9

WEIGHT DROP - MOIST CLAY - GEOPHONES

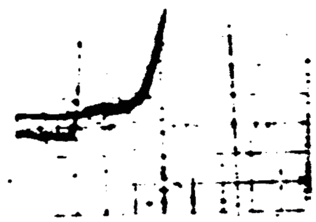
1:794-61
1:794,36-24



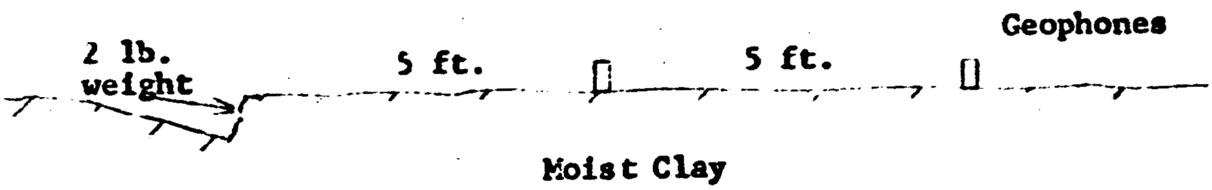
Sweep: 5 ms/div.
Sensi: 0.2 v/div.



Sweep: 2 ms/div.
Sensi: 0.2 v/div.



Sweep: 2 ms/div.
Sensi: 0.2 v/div.



Sweep:	(Given above)
Sensi:	(Given above)
Material Velocity:	1250 ft/sec.
Measured Velocity:	1250 ft/sec.

FIGURE 10

LATERAL WEIGHT - MOIST CLAY - GEOPHONES

1:794-62
1:794.36-25

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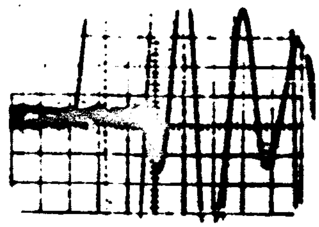
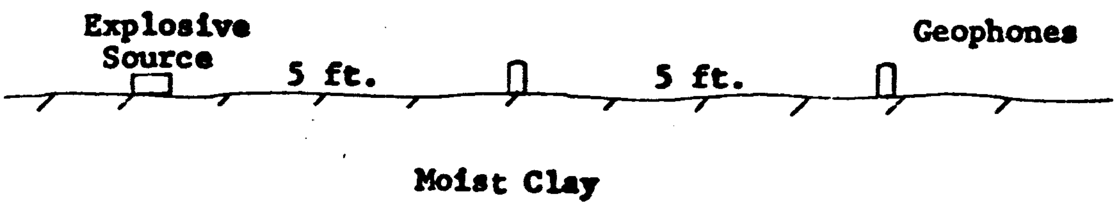


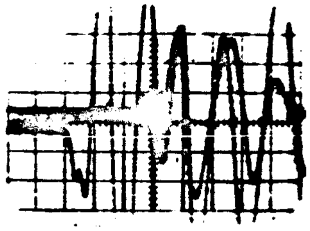


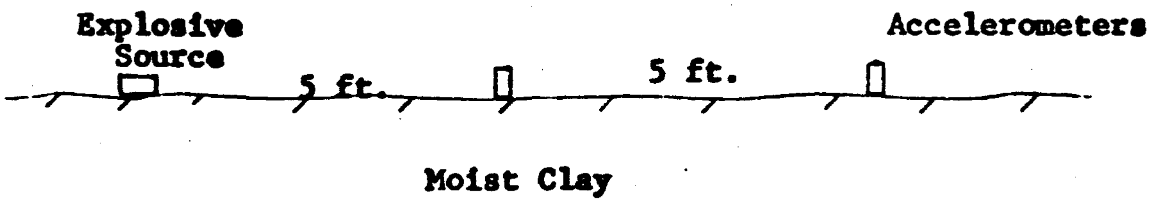
Sweep:	**2 ms/div.**
Sensi:	**0.2 v/div.**
Material Velocity:	**1250 ft/sec. (P-wave)**
Measured Velocity:	**1200 ft/sec. (P-wave)**

FIGURE 11

EXPLOSIVE SOURCE - MOIST CLAY - GEOPHONES

1:794-63
1:794.36-26





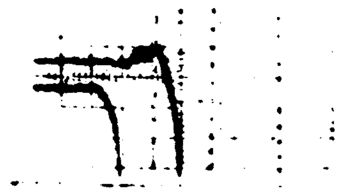
Sweep:	2 ms/div.
Sensi:	0.5 v/div.
Material Velocity:	1250 ft/sec. (P-wave)
Measured Velocity:	1000 ft/sec., Δt
	1250 ft/sec., 1st receiver

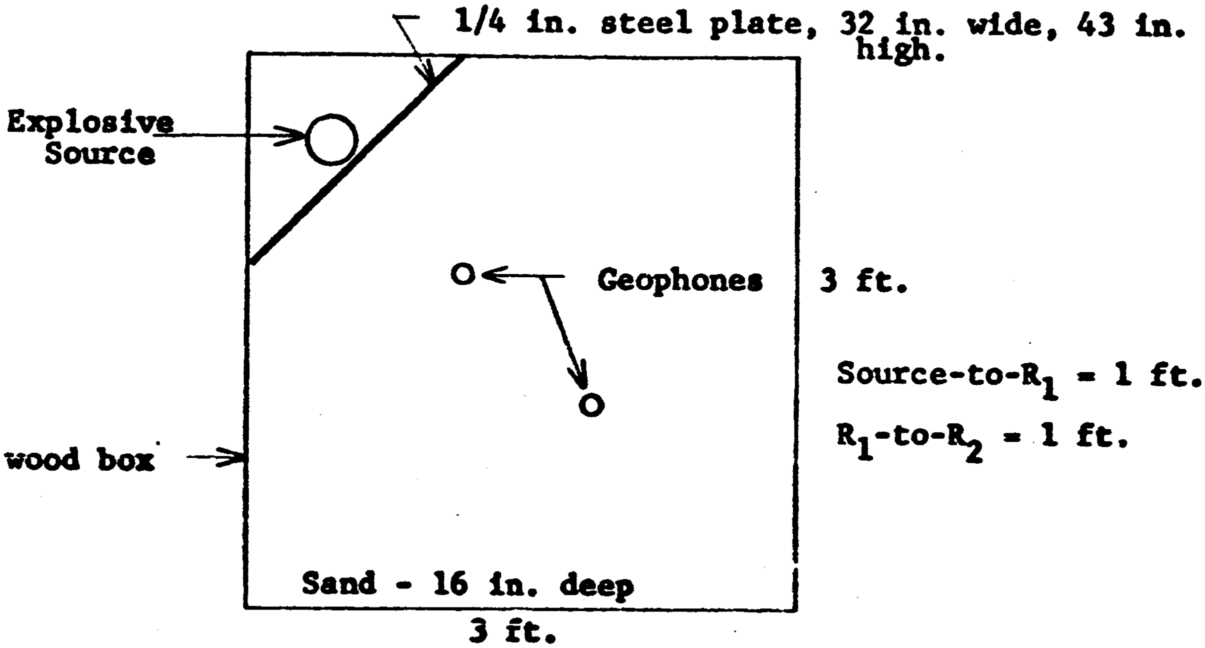
FIGURE 12

EXPLOSIVE SOURCE - MOIST CLAY - ACCELEROMETERS

1:794-64
1:794.36-27

RE-ORDER No. 61-421





TOP VIEW

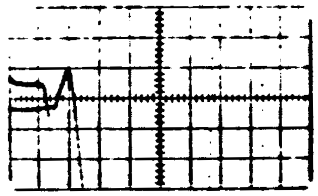
Sweep: 1 ms/div.
Sensi: 1 v/div.
Material Velocity: 550 ft/sec. (P-wave)
Measured Velocity: 500 ft/sec. (discounting air wave on detector No. 2)

FIGURE 13

EXPLOSIVE SOURCE - DRY SAND - GEOPHONES

1:794-65
1:795.36-28

RE-ORDER No. 61-421



Note:

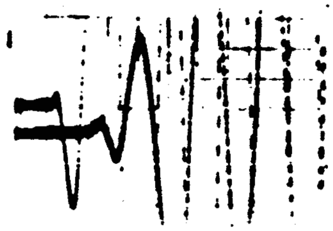
Geometry, material, and detectors, same as in Fig. 13. Explosive source is mounted in metal-rubber enclosure.

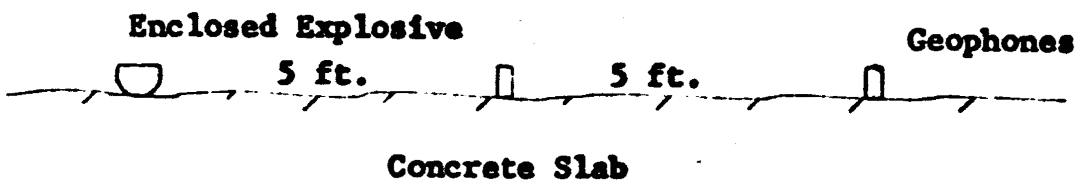
Sweep:	2 ms/div.
Sensi:	0.5 v/div.
Material Velocity:	550 ft/sec. (P-wave)
Measured Velocity:	500 ft/sec. (discounting air wave on detector No. 2)

FIGURE 14

ENCLOSED EXPLOSIVE SOURCE - DRY SAND - GEOPHONES

1:794-66
1:794.36-29





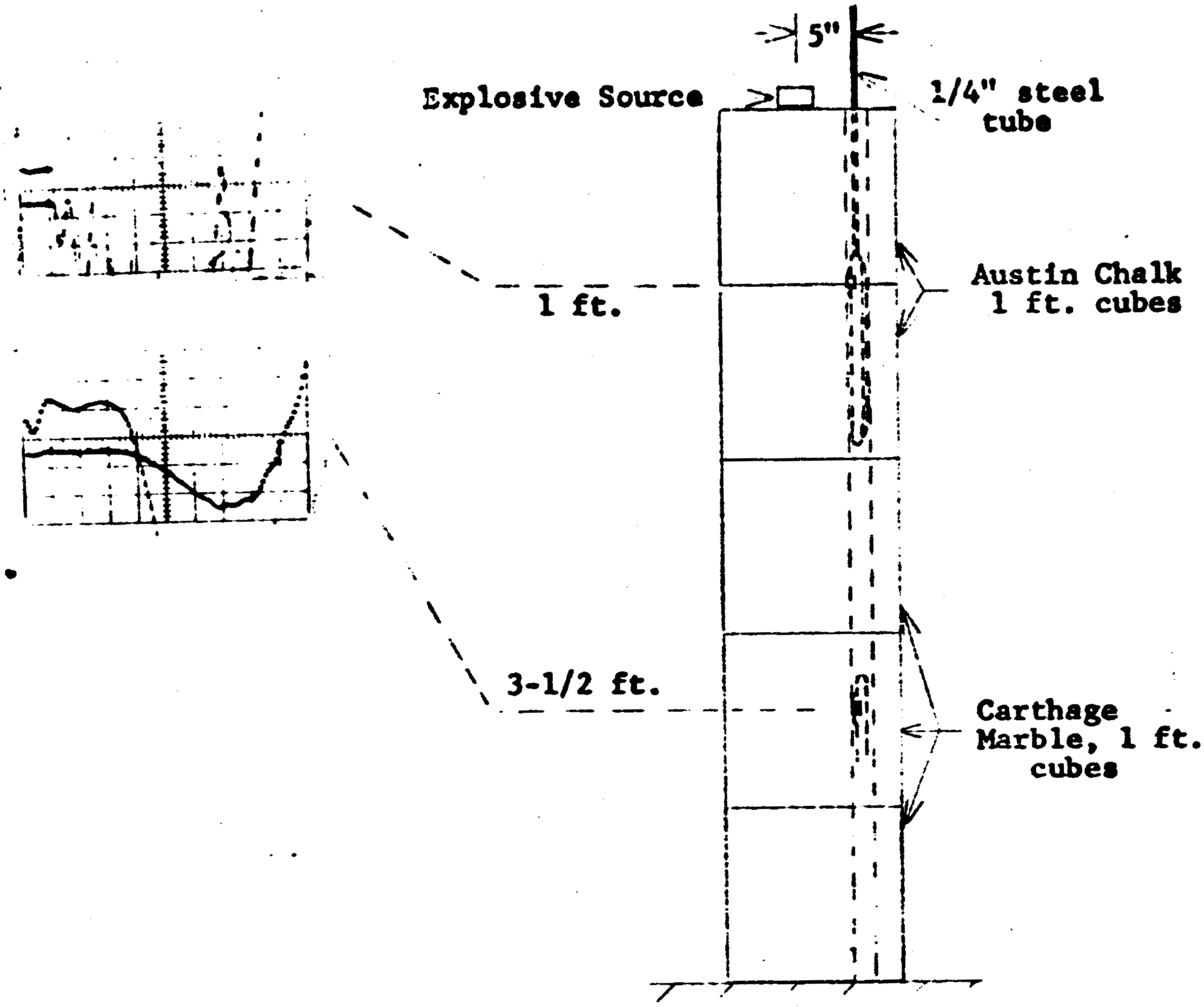
Sweep:	0.5 ms/div.
Sensi:	0.1 v/div.
Material Velocity:	16,600 ft/sec. (P-wave)
	8,500 ft/sec. (Rayleigh)
Measured Velocity:	8,300 ft/sec. (Rayleigh)

FIGURE 15

ENCLOSED EXPLOSIVE SOURCE - CONCRETE - GEOPHONES

1:794-67
1:794.36-30

RE-ORDER No. 61-421



Sweep:	0.1 ms/div.
Multiple Sensitivity:	1.0 and 0.1 v/div.
Material:	Austin chalk and Carthage marble
First Arrival Time, 1 ft.:	0.12 ms.
3.5 ft.:	0.33 ms.
Measured Velocity:	Austin chalk - 10,000 ft/sec.
	Carthage Marble - 13,500 ft/sec.

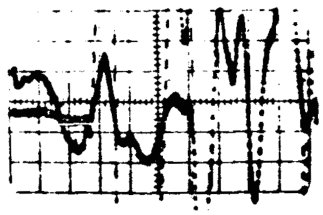
FIGURE 16

DOWNHOLE VELOCITY - HARD ROCKS - EXPLOSIVE SOURCE

1:794-68

1:794.36-31

RE-ORDER No. 61-421



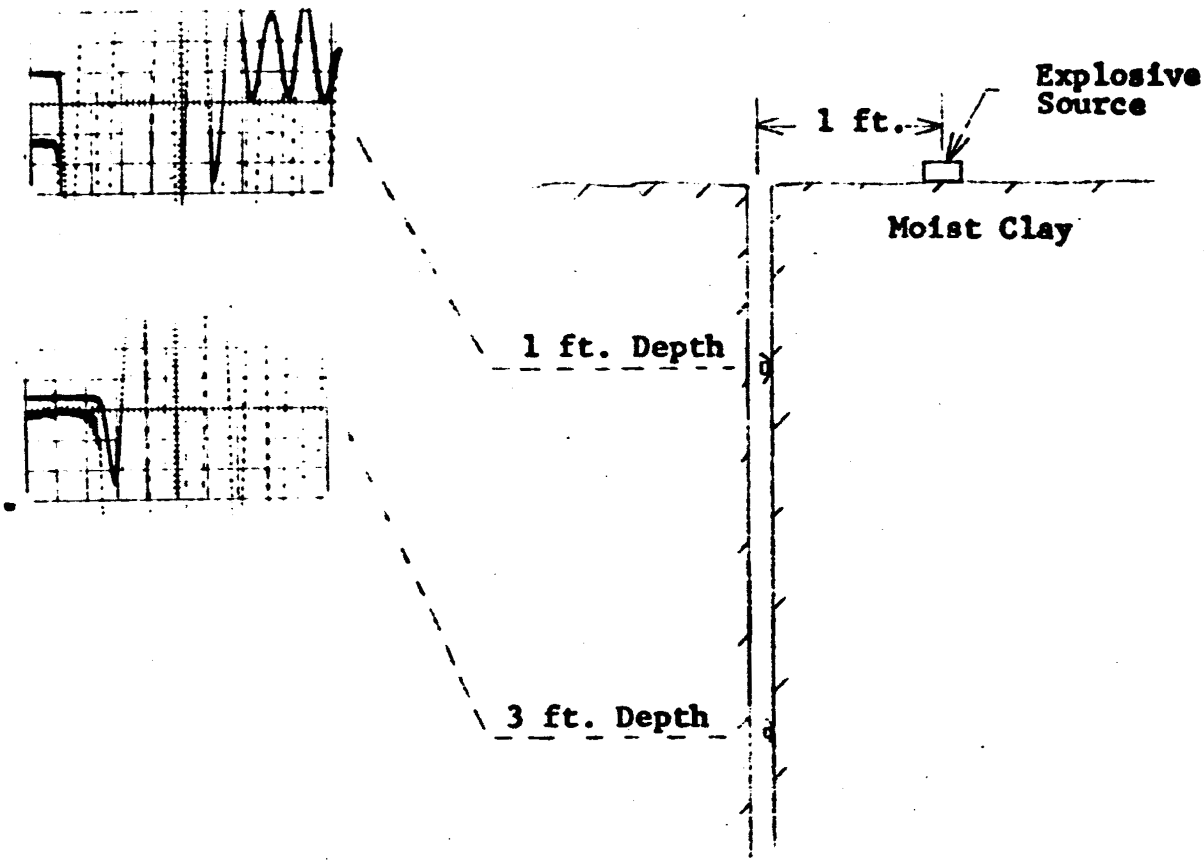
Test Conditions: Same as in Fig. 16 except that 1.5 in. layer of dry sand placed on top rock, under explosive source. Depth of detector was 3.5 ft. plus the 1.5 in. of sand.

Sweep: 0.5 ms/div.
Multiple Sensitivity: 2.0 and 0.2 v/div.
First Arrival Pick: 0.6 ms.

FIGURE 17

DOWNHOLE VELOCITY - HARD ROCKS - EXPLOSIVE SOURCE
SAND SURFACE

1:794-69
1:794.36-32



Sweep:	1 ms/div.
Multiple Sensi:	1 ft. depth - 0.5 and 5.0 v/div.
	3 ft. depth - 0.2 and 2.0 v/div.
Time Pick, 1 ft. Depth:	0.9 ms.
3 ft. Depth:	2.0 ms.
Measured Velocity:	1550 ft/sec.

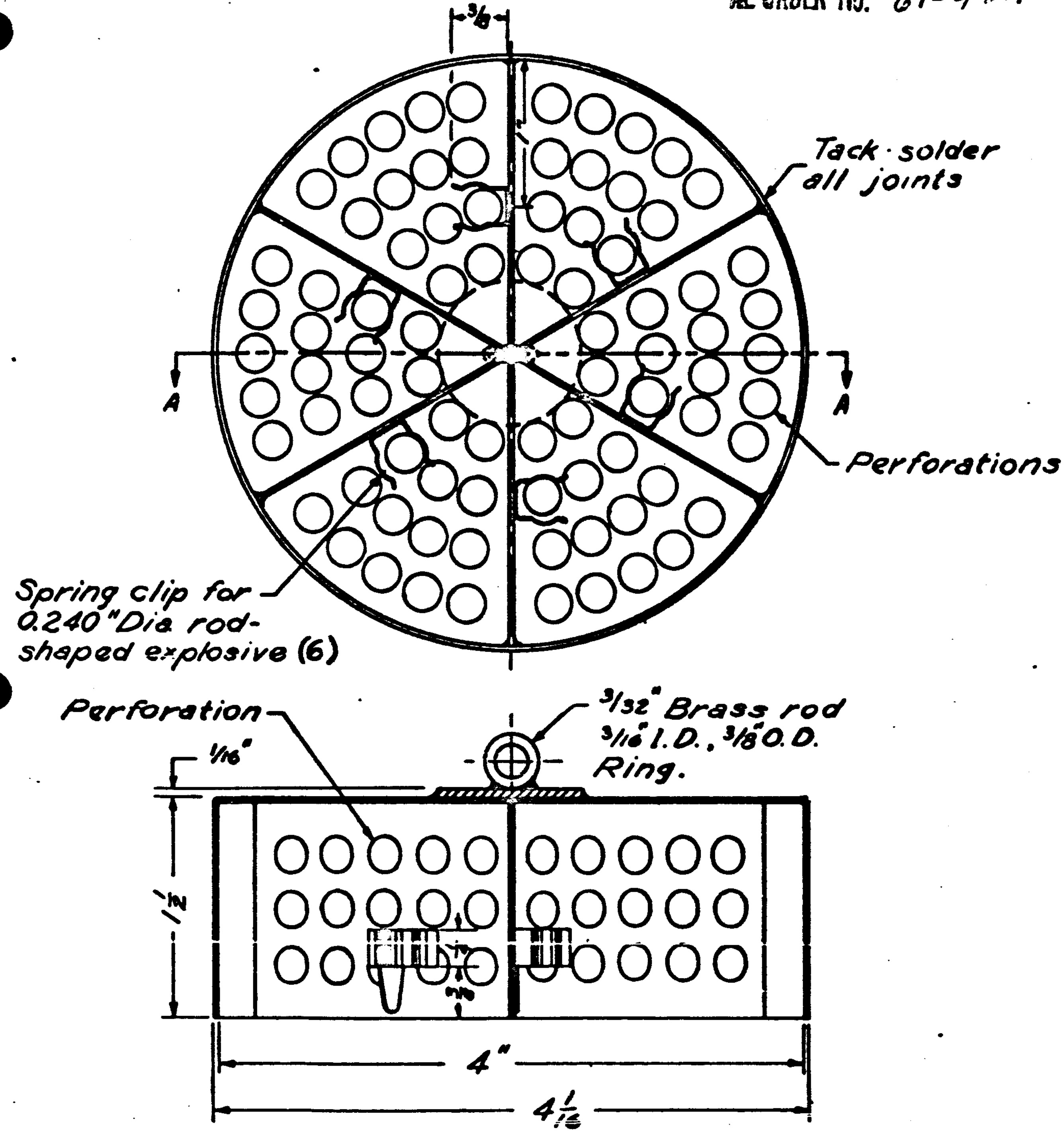
FIGURE 18

DOWNHOLE VELOCITY - MOIST CLAY - EXPLOSIVE SOURCE

1:794-70
1:794.36-33

FIGURE 19

RE-ORDER No. 61-421



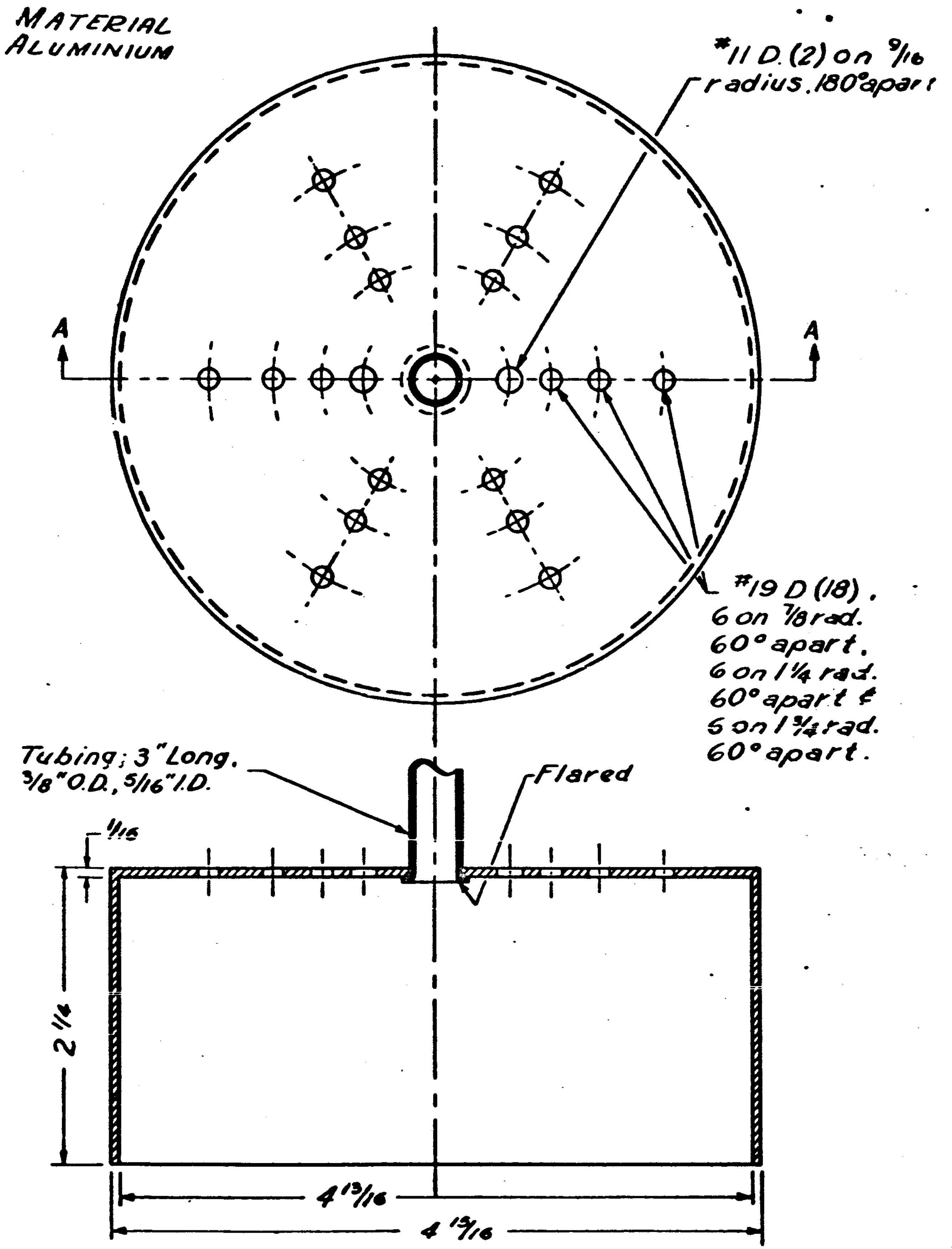
Section A-A

MATERIAL: Sheet material brass, 1/32" with 1/4" perforations on 3/8", centers. Ring plate 1/16" brass Spring Cligs, Bery. Cop. (6)

BREADBOARD ACOUSTIC SOURCE HOLDER

1:794-71
1:794.36-34

FIGURE 20



Section A-A
SOURCE HOLDER
ENCLOSURE FOR VACUUM TESTS

1:794-72
1:794.36-35